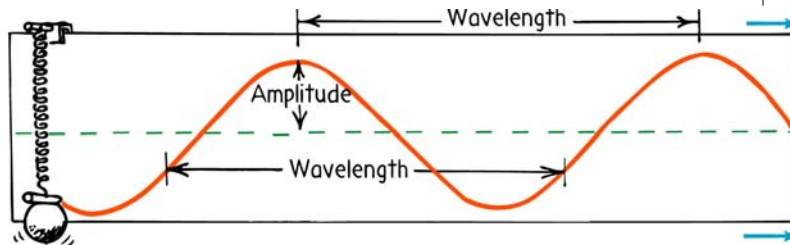
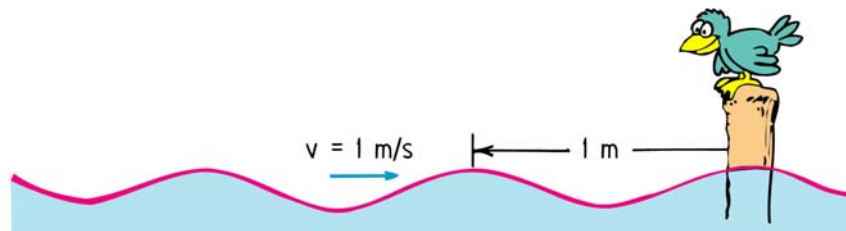


Vibrations and waves



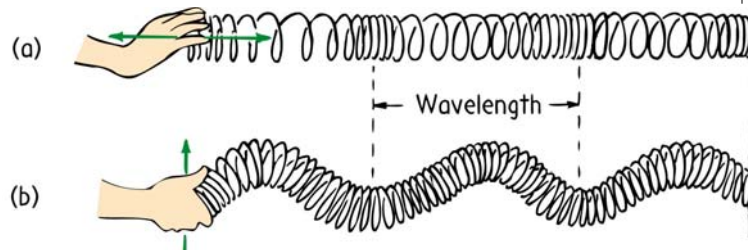
- Maxima and nodes
- Frequency and period
 - Hertz (Hz) = 1 per second
- Speed = wavelength \times frequency ($v = \lambda u$)
 - [demonstration](#)

Wavelength, frequency and velocity



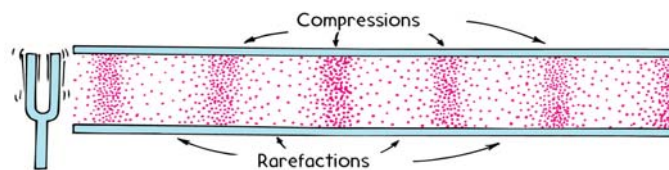
- Maxima and nodes
- Frequency and period
 - Hertz (Hz) = 1 per second
- Speed = wavelength \times frequency ($v = \lambda u$)

Longitudinal and transverse waves



- [Transverse waves](#)
- [Longitudinal waves](#)

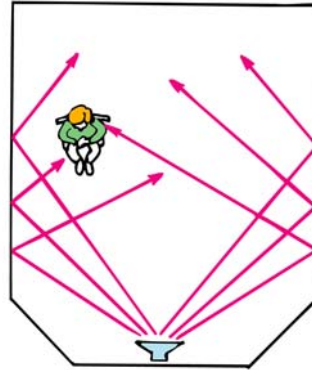
Compressions and rarefactions in (longitudinal) sound waves



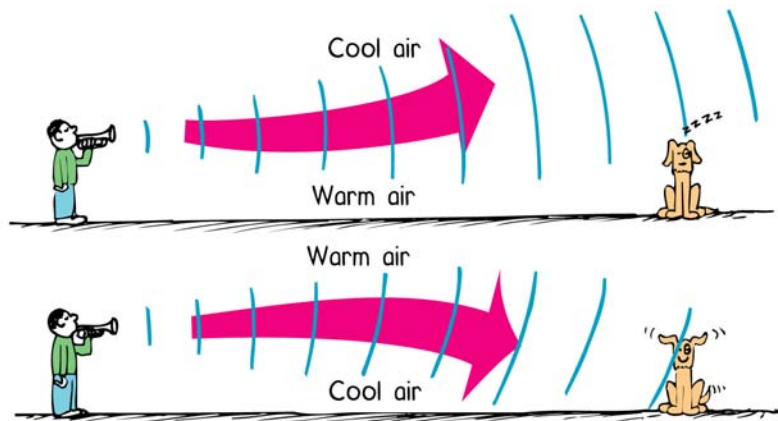
- The speed of sound depends on density
 - [demonstration](#)

Waves can be reflected

- [Demonstration](#)

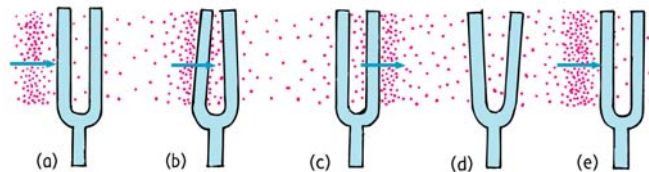


Waves refract: why?



[demonstration](#)

Resonance is caused by forced vibrations



- [Finding the resonant frequency](#)
- Resonance in musical instruments
- Resonance in structures
 - [Demonstration](#)

Wave superposition



- Constructive interference

- [Demonstration](#)

- Destructive interference

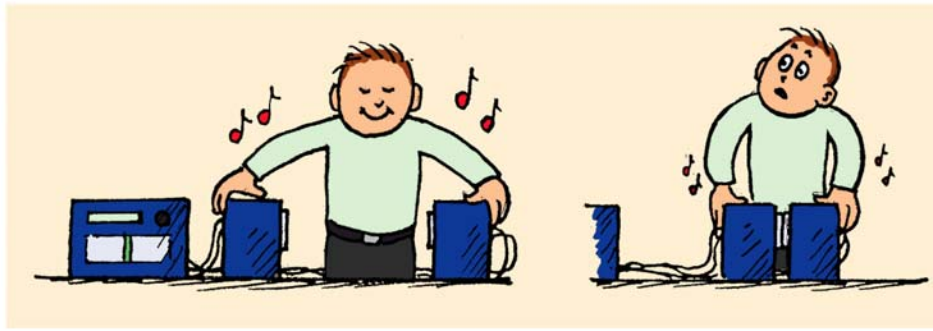


The superposition of two identical transverse waves in phase produces a wave of increased amplitude.



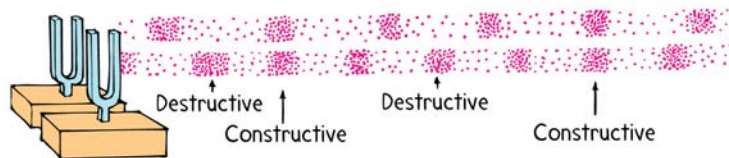
The superposition of two identical longitudinal waves in phase produces a wave of increased intensity.

Two-speaker interference



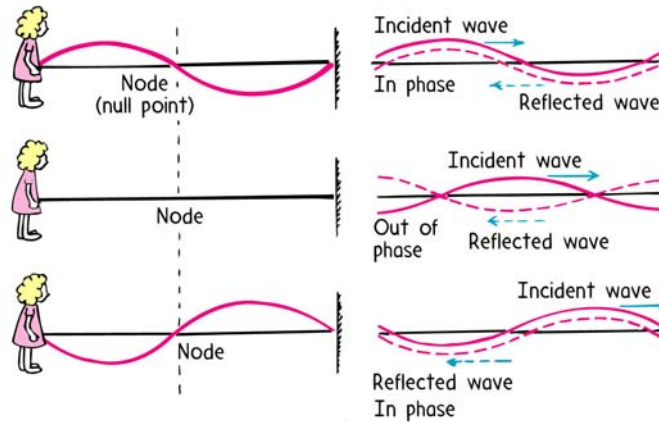
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Beats



- Caused by waves with different frequencies
 - [demonstration](#)

What is a “standing wave”?

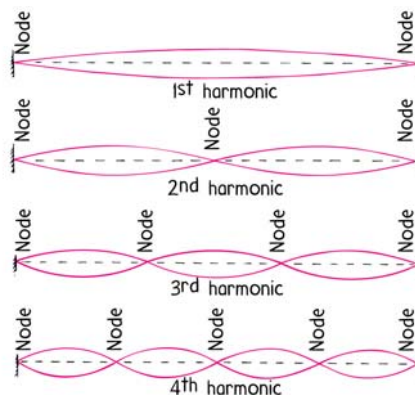


[transverse](#)

[longitudinal](#)

[in musical instruments](#)

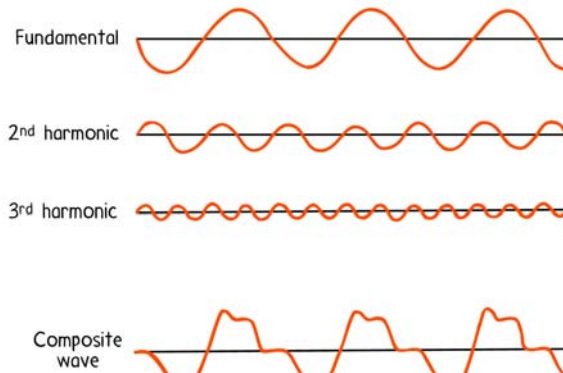
Standing waves and harmonics



- Fundamental
- Second harmonic
 - Octave
- Third harmonic
 - octave + fifth
- Fourth harmonic
 - two octaves



If several harmonics are produced simultaneously...

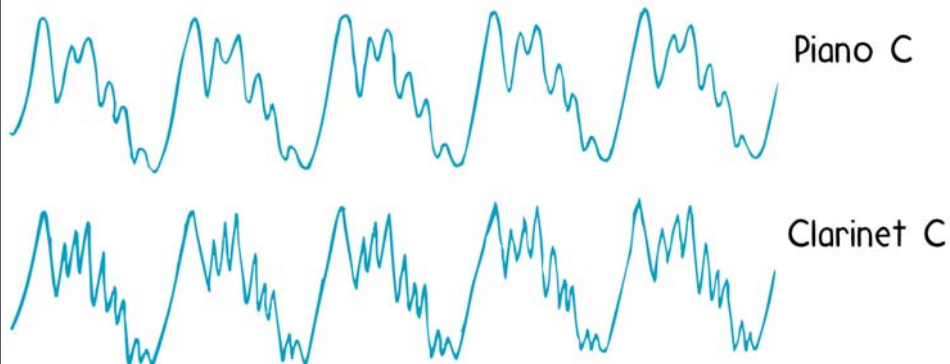


[pure tone](#)

[composite tone](#)

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Different instruments have different timbres



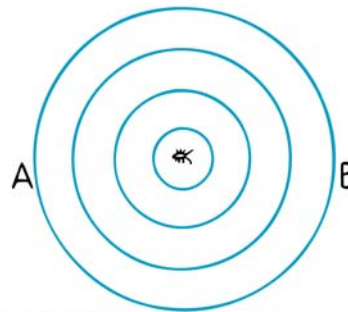
The Doppler effect



What's going on?



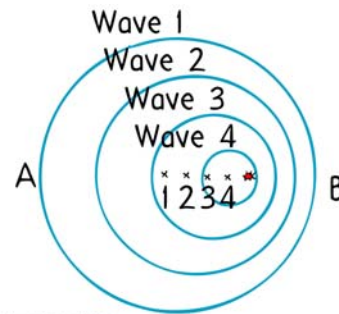
- Stationary sound source



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What's going on?

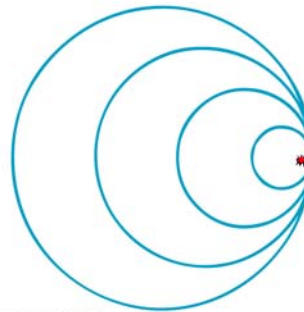
- Moving sound source



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What's going on?

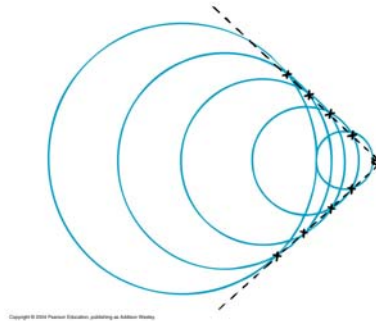
- Moving sound source
 - At the speed of sound



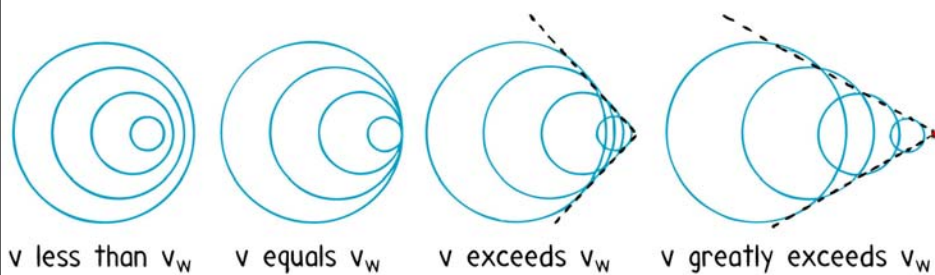
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What's going on?

- Moving sound source
 - Past the speed of sound



Bow waves and shock waves



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